DESIGN AND ANALYSIS OF AUTOMOBILE WHEEL RIM USING DIFFERENT FILLET RADIUS AND DIFFENET Y SPOKE ANGLE

Mr. GOURAW BEOHAR[1], Mr. ARUN KUMAR MALVIYA[2], MONIKA NAMDEV[3]

[1]*Professor, Dept of Mechanical Engineering, Shri Ram Institute of Technology, Jabalpur, Madhya Pradesh, India*
[2]*Professor, Dept of Mechanical Engineering, Shri Ram Institute of Technology, Jabalpur, Madhya Pradesh, India*
[3]*Student, Dept of Mechanical Engineering, Shri Ram Institute of Technology, Jabalpur, Madhya Pradesh, India*

---***---

Abstract – Wheel rims are the most important part of automobile, in an automobile there are fatigue loads and static loads which are actively participated in design. There are several way of failure of wheel rim like critical stresses and material failure due to design, dimension and shape of wheel also play vital role in its rim design. Present paper studied the Y angle optimization in alloy wheel rim. The present project design is modeled by using modeling software CATIAv5, imported analyzed by ANSYS software.

For the structural analysis for the remote force the magnitude applied is 1000N and for the pressure which applied on the wheel is 245kPa.

Finally result shows the total deformation of 8 spoke alloy wheel with 55° Y spoke angle, figure clearly depicted the total deformation maximum value 0.00155mm maximum at base of wheel or outer periphery of wheel rim.

Key Words: Wheel Rim, Y Spoke Rim, fillet radius of rim, total deformation occurring,

1. INTRODUCTION:

Origin of human civilization is truly stated with invention of wheel and absolutely it is significant discovery of evolution of human race. The invention of wheel accelerates the transportation idea. By definition, wheel is a part with circular shape which rotates around axle and enable the rolling motion of vehicle. Inception concept of wheel is simply wooden disk with hole manufactured for cart or bullock cart. Wheel with spoke is used for construction of lighter and speedy vehicle. Designing and production of modern motor vehicles follows strict guidelines to ensure safety of travelers. Each component of vehicle may have to follow criticality of each design consideration. Simply the automobile wheels distinguished as per international coding system.

There are three elements in wheel classified as hub, spokes, and rim. Components related to design may be constructed in one or multiple parts. Firstly, the hub is basic centrally located and attached through wheel knuckle. Secondly the spokes act as bridge between hub and rim. At last, the rim which is outermost part of wheel to grasp type. There are few essential characteristics for wheel of vehicle. Wheel should be in proper balancing in statically and dynamically both conditions. Wheel should be light in weight with ease in mounting and removing. Wheel material should have good in strength as well as less corrosive to weather conditions. The wheel has well in steering control and able to absorb shock loads, it should also be able to resist deformation against impact load during bump.

1.1 Steel and Aluminum Wheels

More popular and standard part of vehicles. They also added the sophistication to vehicle with light weighting Constructions of wheel for modern cars have started with steel wheels which are usually constructed with metal sheet and then welded together. Due to durability, flexibility, and greater strength of material like steel they are still in use, but the disadvantage with steel wheels is their heavy weight.

To reduce the weight in car wheels to achieve better stability and dynamics of vehicles, car manufactures introduced the aluminum wheels as add-ons to vehicles. But technologies shifted to more organized sectors and aluminum wheels become measure, as well as stylish feature in cars. Aluminum modeled wheels started its flagship to all luxury vehicles with exclusively personnel touched reason.

In 1948 forged aluminum wheel invented in ALCOA and 1962 the Porsche with aluminum alloy increases the popularity of forged aluminum wheels. The penetration of aluminum in wheels was approx. 35 % in the year in European context, which is near about 1.5 times as compare with USA and Japan. Now a days aluminum wheels increase their popularity in commercial market. Nowadays, the growth rate of the aluminum wheel market has slowed down, but the market volume is still increasing.

1.2 Manufacturing of Aluminum Wheels

In modern days the aluminum wheels are made by casting and forging processes. Performance of wheels is directly propositional to the manufacturing process. Their performance is a direct result of the employed manufacturing technique. Forged wheels are stronger one as well as lighter. Casting wheels are known as durable ones for moderate conditions. The manufacturing of wheel classified into two types as per manufacturing process

i. Cast aluminum wheels
ii. Forged aluminum wheels

1.3 Aluminum Alloy Wheels

Alloy wheels are basic combination of two materials: aluminum and magnesium. Basically, two types of alloy type used in manufacturing in wheels, first is AlSi1MgMn (6082) and other AA 6061 (AlSiMgCu). Recently manufacturing with Titanium is being measured for better durability and shock absorbing. Different Spoke design is also considered for better durability and design consideration, and it should be able to face all consequences while riding the vehicles in all terrains of roads.

Magnesium alloy wheels are sometimes used on special cars (sports cars, upper class models) for better performance instead of heavier steel or aluminum wheels. These wheels are produced by hot forging or casting from magnesium alloys such as ZK60, AZ31 or AZ91. Their typical mass is about 5–9 kg (depending on size). But apart from the high price, magnesium wheels have also additional disadvantages for normal road use (flammability, corrosion resistance)

2. LITERATURE SURVEY

P. Meghashyam et.al studies the car wheel rim designed by CATIA to reduce the risk involved in manufacturing and design. Further it is analyzed by ANSYS software, in this analysis the 3D model exported and simulated with different forces and pressure. ANSYS used static model of analysis, where two different models of aluminum and forged steel were calculated for wheel rim component. Structural behavior of rim model analyzed by input data of software, calculation of different rim model ANSYS workbench is used with different materials like Steel, Aluminum alloy, Titanium alloy, Magnesium alloy. A standard rim size i.e. 17 Inch taken for analysis as per SAE standard with fixed ends for lug holes. Total 0.35 MPa applied on the wheel barrel with different materials. In all four possibilities the best suited material is aluminum, the second best material is titanium alloy, but high cost makes the titanium alloy non-commercial.

Hence, titanium alloy is better suitable material if cost is no issue; otherwise Aluminum Alloy among these four materials is good for wheel rim obtained from this research analysis.

Sunil Prashanth Kumar et. al studies the aluminum alloy and steel rim, designed in Auto CAD 2022. The project is analyzed with ANSYS software with two category steel and aluminum alloy. Study occurred in two design first simply six spoke design and second one is multi spke alloy, where total force applied is 1000N and pressure 245 kPa. In result comparsion alloy wheels have less deformation as compared with steel ones. In design format there is multi spoke alloy have better results than6 spoke alloy wheels.

Manugonda Babu et al researches on shape and dimension constraint of wheel rim basically. The modeelling of wheel rim initiated in CATIA by 3D model, further work of analysis is done by ANSYS software, where different constraints like deformation, strains and stress are calculated. Overall analysis is considered on different material wheel rim like carbon fibre, aluminum and Kevlar. Wheel rim also subjected with fatigue structural analysis. This research also recommended the best material and weight comparison between all materials chosen. Along with these materials Kevlar chosen with best suitable material with all constraints like fatigue and weight reduction.

M.Ravichandra et al studied different auto motive wheels with different materials like carbon epoxy, E glass and S glass. Alloy wheels have better stability control with greater steering quality and less in weight. In this paper composite materials studied with their data of present automobile, results are compared with all other data with existing model. In this project a parametric model is designed for Alloy wheel used in four-wheeler by collecting data from reverse engineering process from existing model. The designed model analyzed with ultimate strength of three composite materials with help of Pro- E model and Ansys Model.

3. METHODOLOGY:

In study of automobile wheel rim, different review suggested the different stresses during loading. Basically, wheel rim is subjected with bending and torsional load. The basic need of better rim structure is long life, weight reduction and material selection for better manufacturing. In commercial world the need of low manufacturing cost as well as less weight and low cost is necessary. There are competitions among materials and manufacturing processes, due to cost performance and weight.

In present research work FEM is most promising method to understand different parameters of design. The finite element method is computational method to calculate different parameter of design by introducing different boundary condition. The mathematical problem in which differential equations set with variables with specific boundary conditions to obtain different results. The iterative mathematical processes like as Galerkin's weighted residual method and Raleigh-Ritz methods castoff to gain the finite element formulation of the partial differential equation. ANSYS Static Structural is a valuable tool for examine problems connecting contact, huge distortions, nonlinear materials, high frequency reaction phenomena and problems needing explicit explanations.

4. TYPES OF WHEEL DESIGN:

Designing the alloy wheels are based on the manufactures but the steel wheels are same for every manufacture, so the different designed models are

4.1 Spoke Alloy Wheel

Here the material and the properties are used based on the aluminum alloy. Totally, six spokes are there in this alloy with dimensions and it is done structural analysis

4.2 Multi-Spoke Alloy Wheel

The material used is same as that of 6 spoke alloy which is aluminum alloy and their properties for the purpose of analyzing it and to identify structural analysis of the wheel. Here more spokes have been designed to find out which one of the alloy wheels has more strength in the structure.

4.3 Steel Wheel

It is designed to identify is steel or the alloy is better in the structural analysis. Steel is the main material used to produce the steel wheel, here the material used for the analysis of the structure is used the structural steel and their properties.

5. WHEEL DIMENSIONS: (in mm):

Dimensions are equal for all the three types of wheels for

6 spoke alloy wheel

Rim diameter = 410mm

Rim width = 465mm

Center bore = 40mm

Bolt circles = 20mm

Spoke length = 200mm

For steel wheel,

Rim diameter = 420mm

Rim width = 245mm

Center bore = 35mm

Bolt circles = 20mm

Circles around the outer area = 25mm

For multi-spoke alloy wheel,

Rim diameter = 420mm

Rim width = 230mm

Center bore = 30mm

Bolt circles = 15mm

Spoke length = 200mm

6. DESIGN AND MODELING:

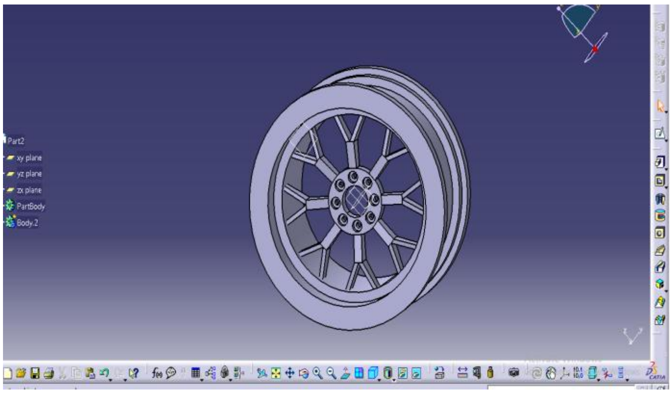

Fig-1: Design Model of 8 Spoke Alloy Wheel

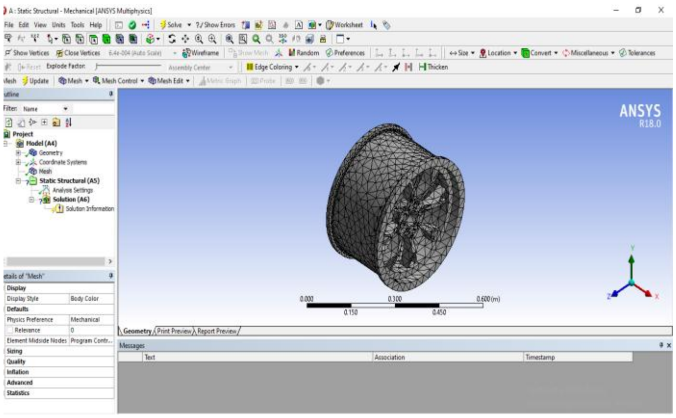

Fig-2: Meshing of 8 Spoke Alloy Wheel

7. ANALYZED MODELS:

7.1 Fillet radius variation

Different model analysis with no filler radius to 5 mm fillet radius varied.

Wheel Rim with No Fillet

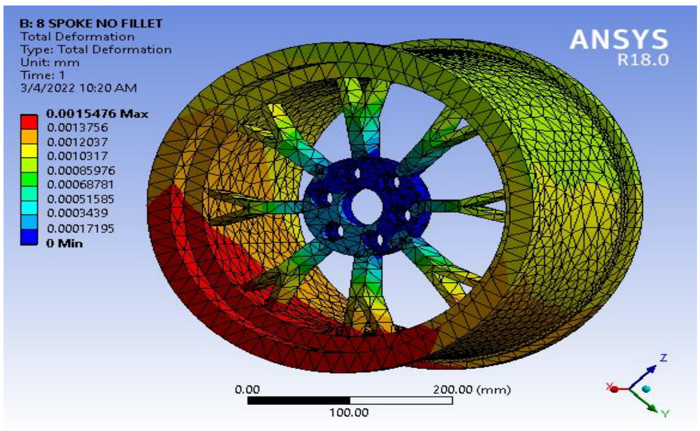

Fig-3: Total Deformation of 8 Spoke Alloy wheel with No fillet radius

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 04 | Apr 2022 www.irjet.net p-ISSN: 2395-0072

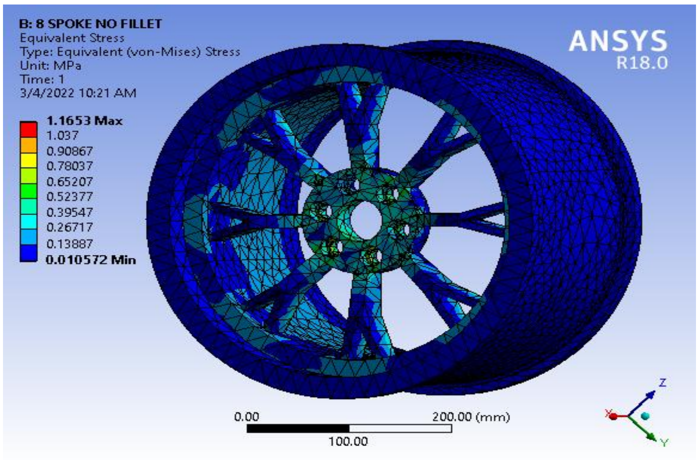

Fig-4: Equivalent Stress of 8 spoke alloy with No fillet radius

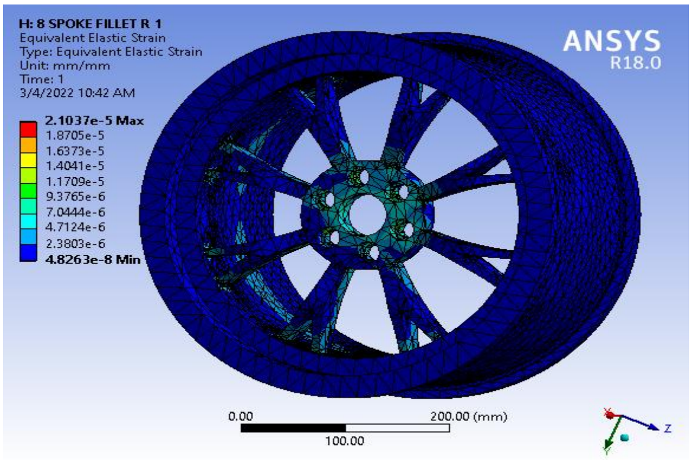

Fig-7: Equivalent Elastic Strain of 8 spoke alloy with 1mm fillet radius

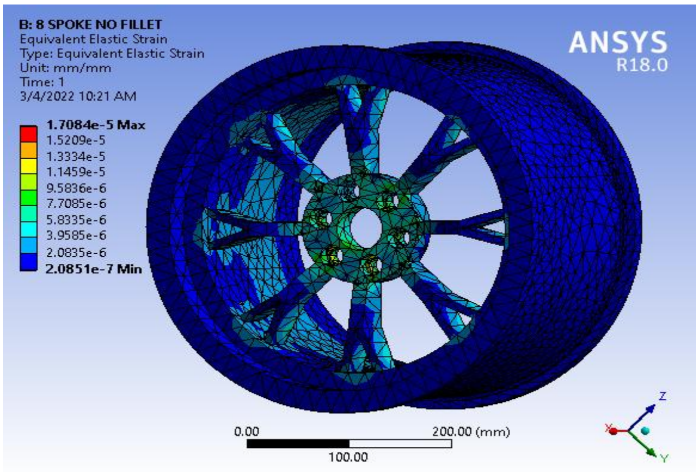

Fig-5: Equivalent Elastic Stress of 8 spoke alloy with No fillet radius

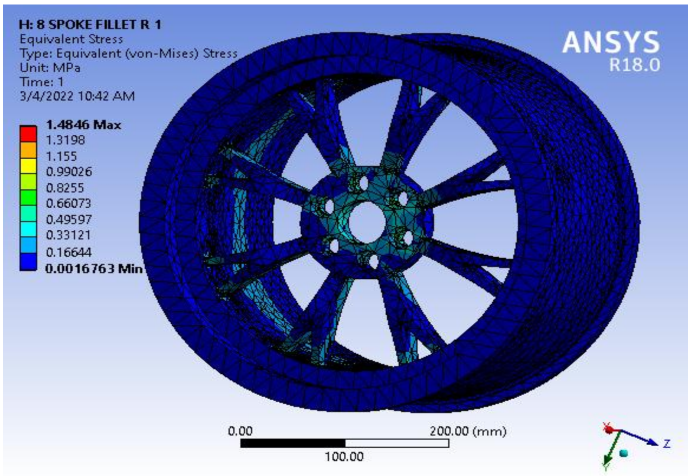

Fig-8: Equivalent Stress of 8 spoke alloy with 1mm fillet radius

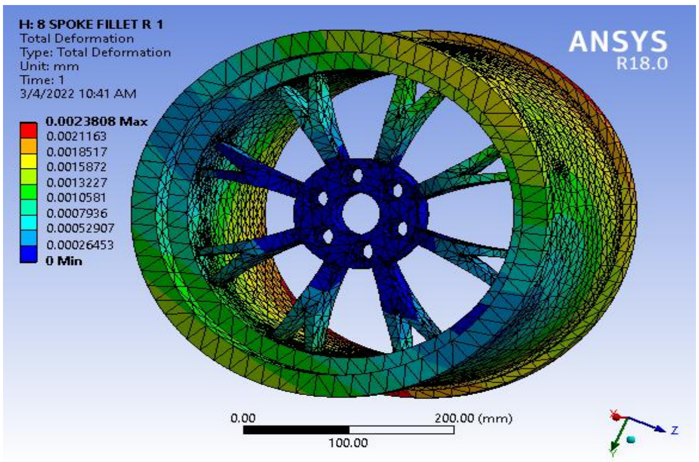

Fig-6: Total Deformation of 8 spoke alloy with 1mm fillet radius

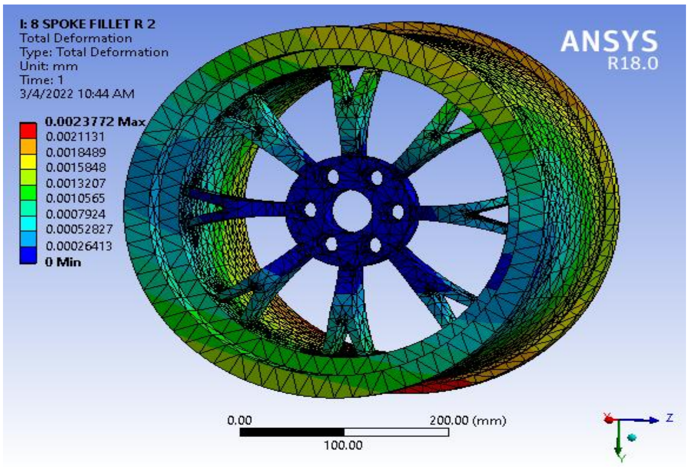

Fig-9: Total Deformation of 8 spoke alloy with 2mm fillet radius

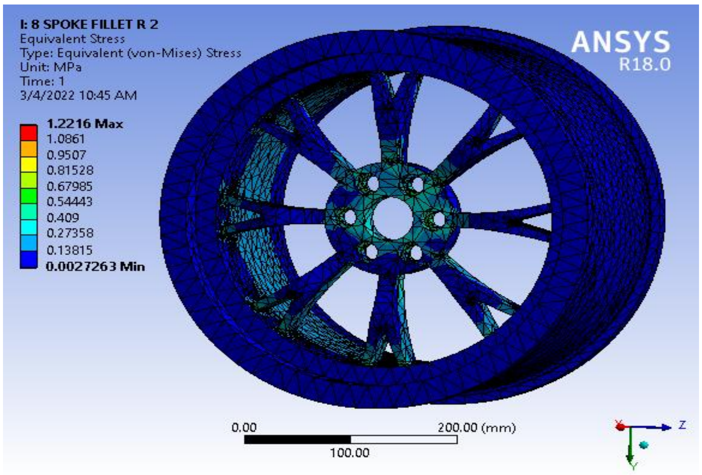

Fig-10: Equivalent Stress of 8 spoke alloy with 2mm fillet radius

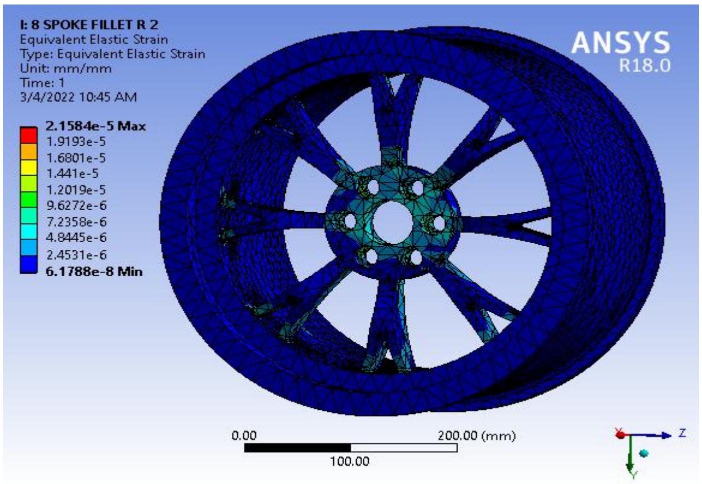

Fig-11: Equivalent Elastic Stress of 8 spoke alloy with 2mm fillet radius

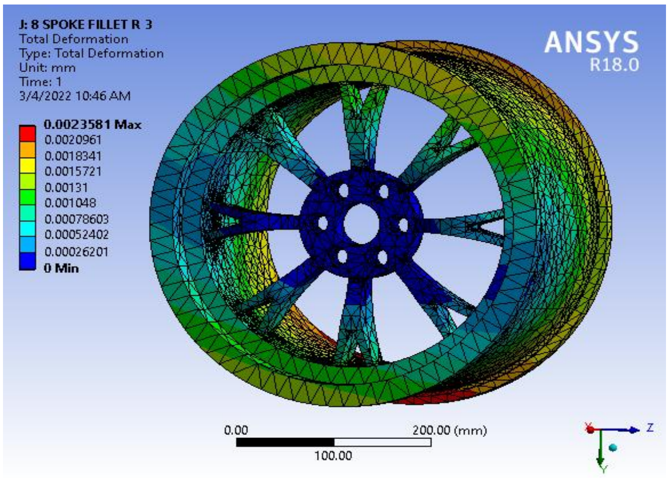

Fig-12: Total Deformation of 8 spoke alloy with 3 mm fillet radius

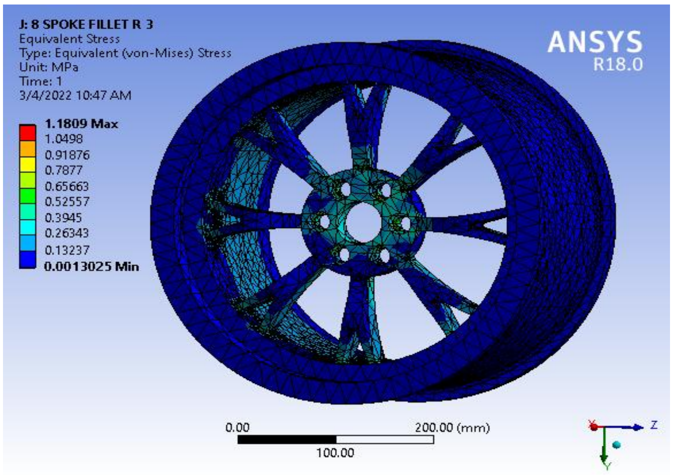

Fig-13: Equivalent Elastic Stress of 8 spoke alloy with 3mm fillet radius

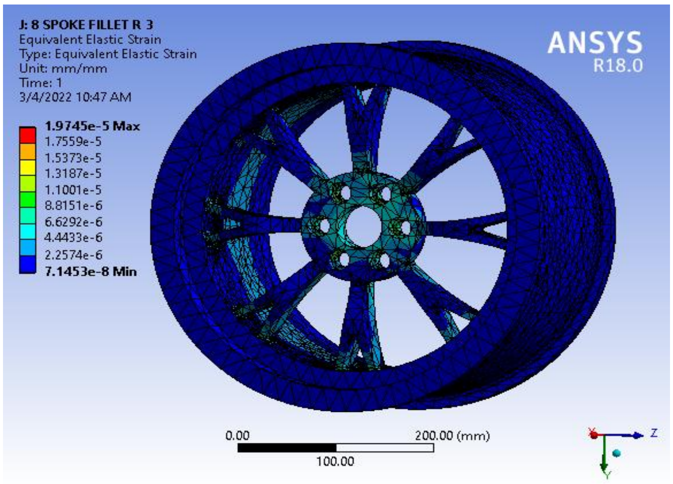

Fig-14: Equivalent Stress of 8 spoke alloy with 3mm fillet radius

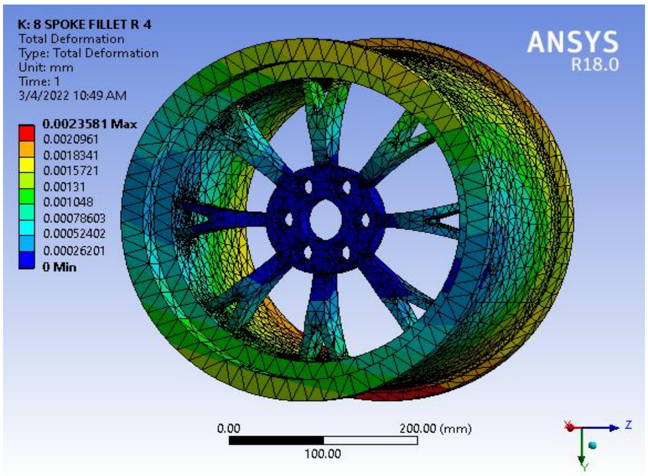

Fig-15: Total Deformation of 8 spoke alloy with 4 mm fillet radius

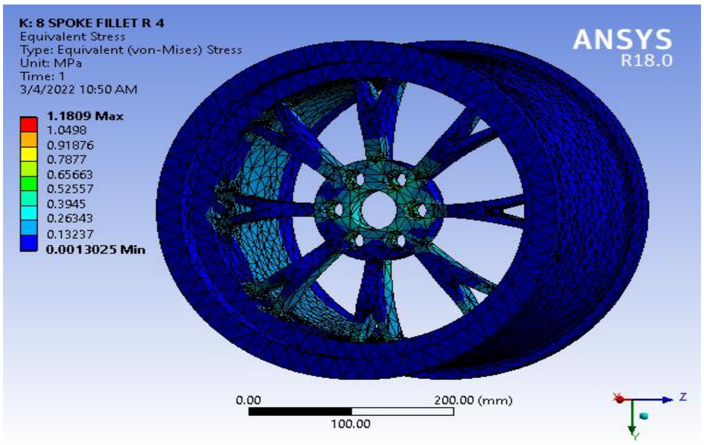

Fig-16: Equivalent Stress of 8 spoke alloy with 4mm fillet radius

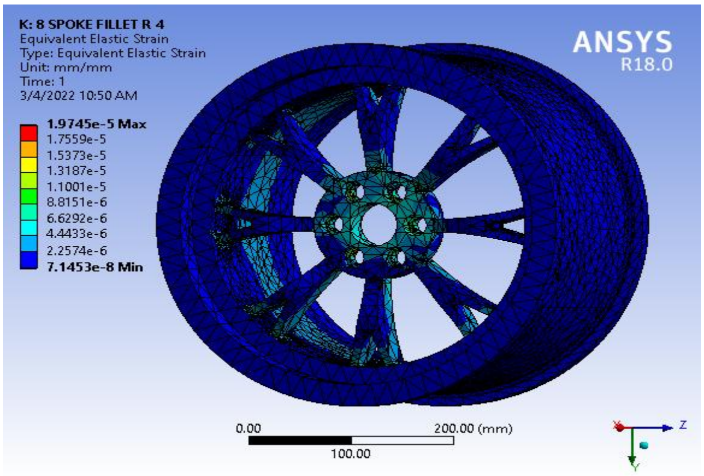

Fig-17: Equivalent Elastic Stress of 8 spoke alloy with 4 mm fillet radius

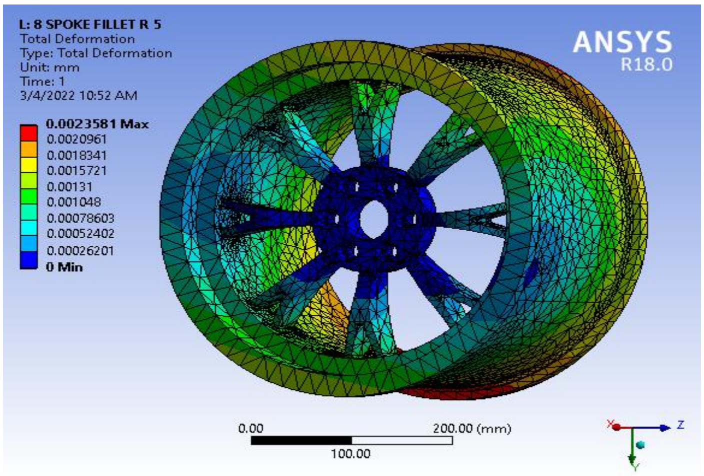

Fig-18: Total Deformation of 8 spoke alloy with 5 mm fillet radius

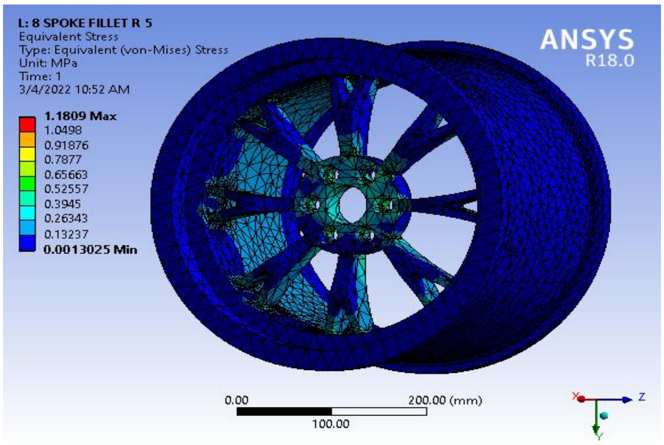

Fig-19: Equivalent Stress of 8 spoke alloy with 5mm fillet radius

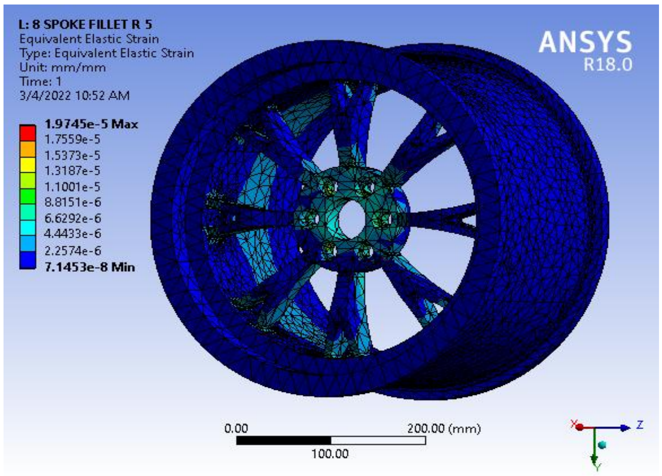

Fig-20: Equivalent Elastic Stress of 8 spoke alloy with 5mm fillet radius

7.2 Y Spoke Angle

Variation in this second model present research emphasis on variation in Y spoke model is carried out with angle with 5degree variation. At first there is 35 degree spoke angle.

Spoke angle with 35-degree angle

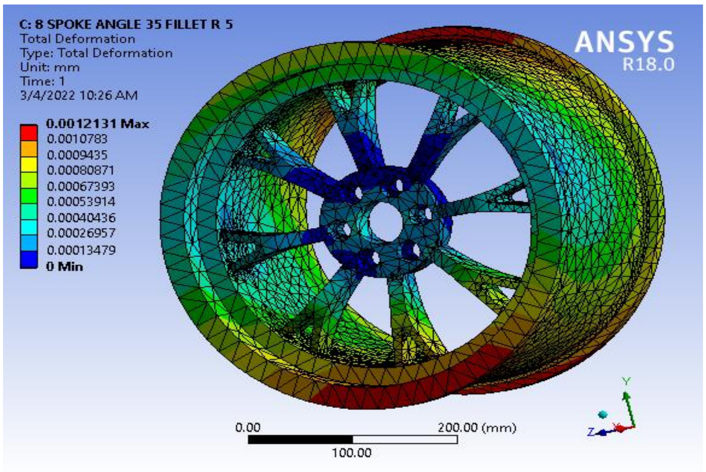

Fig-21: Total deformation of 8 Spoke angle wheel rim with 35º Y spoke angle

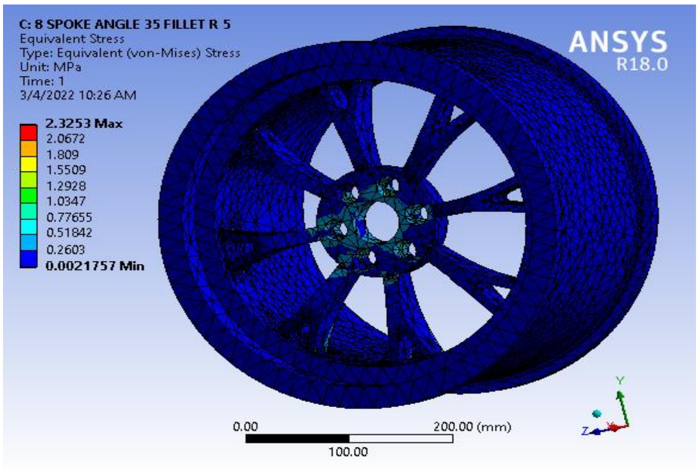

Fig-22: Equivalent Stress of 8 Spoke angle wheel rim with 35º Y spoke angle

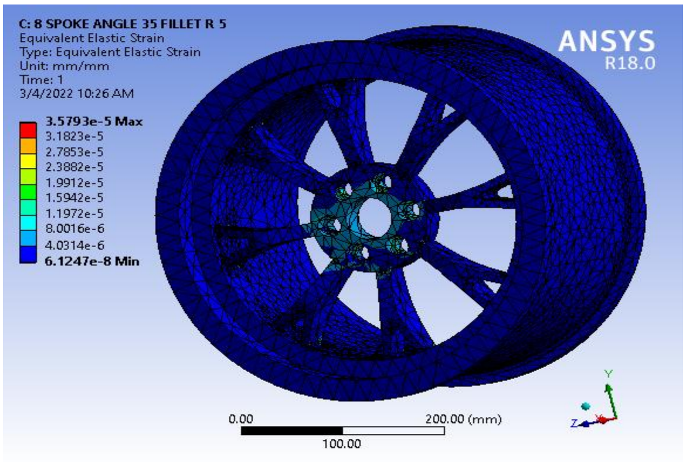

Fig-23: Equivalent Elastic Stress of 8 Spoke angle wheel rim with 35º Y spoke angle

Spoke angle with 40-degree angle

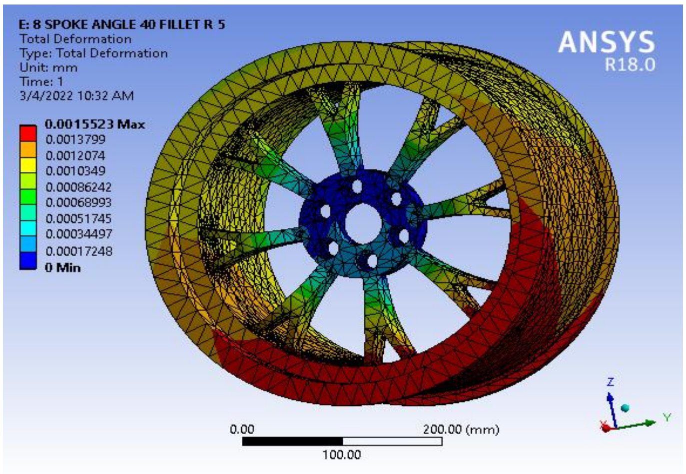

Fig-24: Total Deformation of 8 Spoke angle wheel rim with 40º Y spoke angle

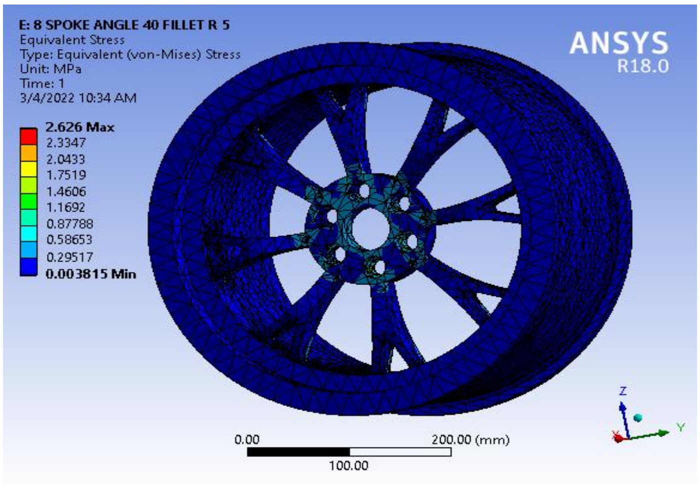

Fig-25: Equivalent Stress of 8 Spoke angle wheel rim with 40º Y spoke angle

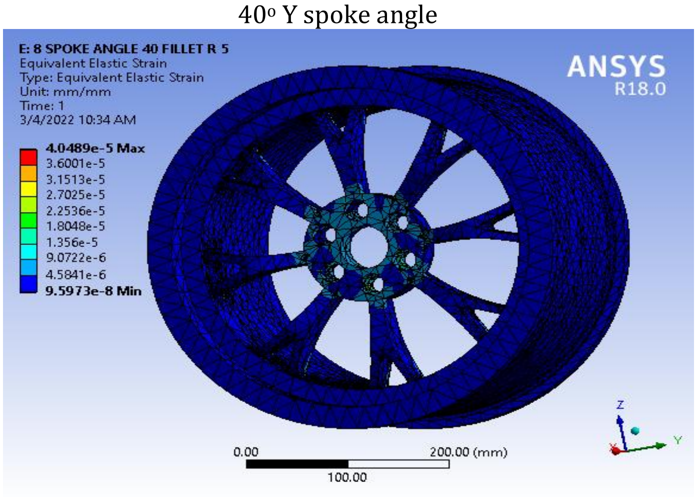

Fig-26: Equivalent Elastic Stress of 8 Spoke angle wheel rim with 40º Y spoke angle

Spoke angle with 45-degree angle

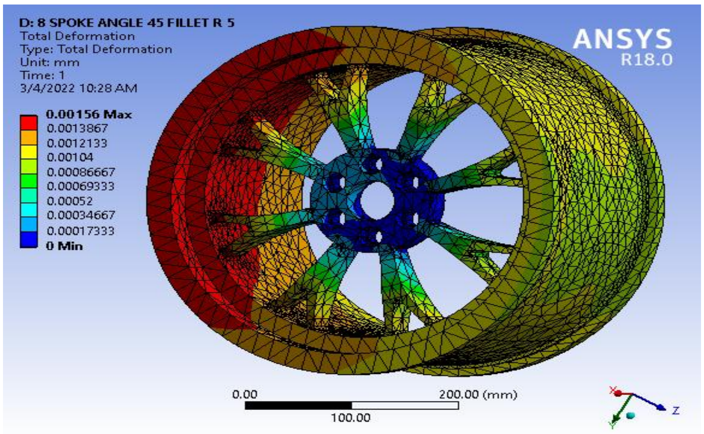

Fig-27: Total Deformation of 8 Spoke angle wheel rim with 45° Y spoke angle

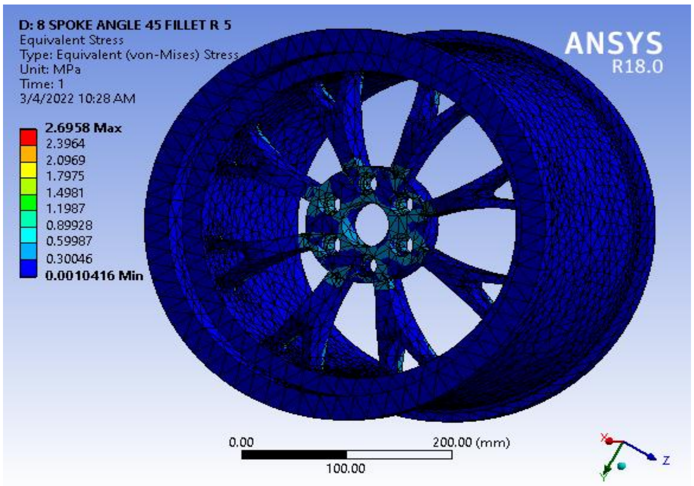

Fig-28: Equivalent Elastic Stress of 8 Spoke angle wheel rim with 40° Y spoke angle

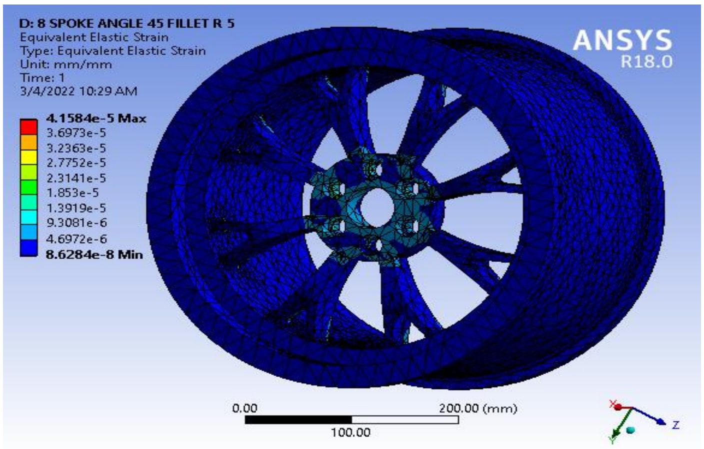

Fig-29: Equivalent Elastic Stress of 8 Spoke angle wheel rim with 40° Y spoke angle

Spoke angle with 50-degree angle

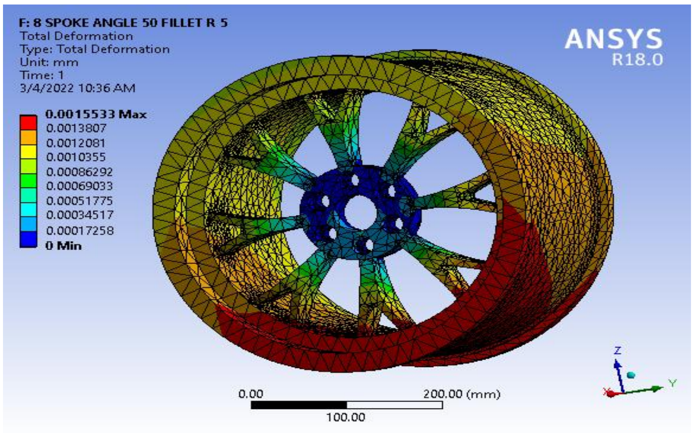

Fig-30: Total Deformation of 8 Spoke angle wheel rim with 50° Y spoke angle

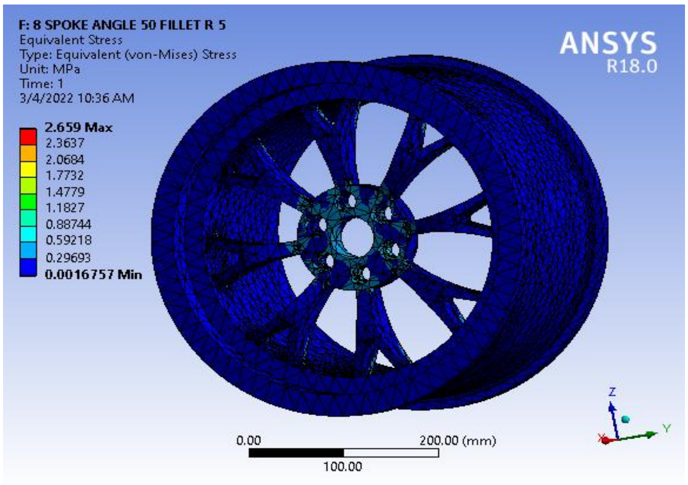

Fig-31: Equivalent Stress of 8 Spoke angle wheel rim with 50° Y spoke angle

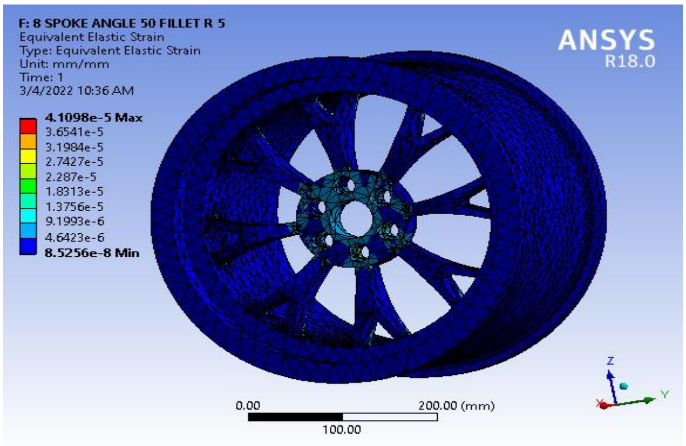

Fig-32: Equivalent Elastic Stress of 8 Spoke angle wheel rim with 50° Y spoke angle

Spoke angle with 55-degree angle

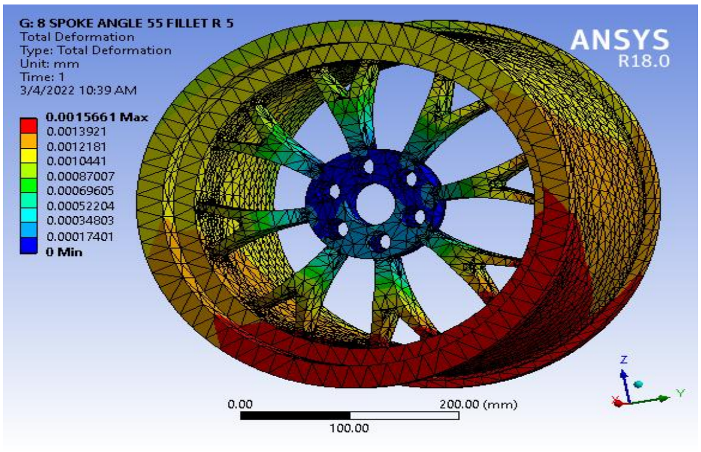

Fig-33: Total Deformation of 8 Spoke angle wheel rim with 55° Y spoke angle

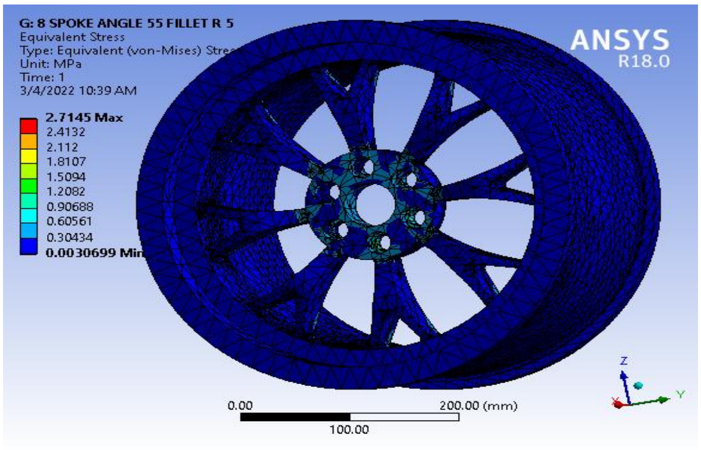

Fig-34: Equivalent Stress of 8 Spoke angle wheel rim with 55° Y spoke angle

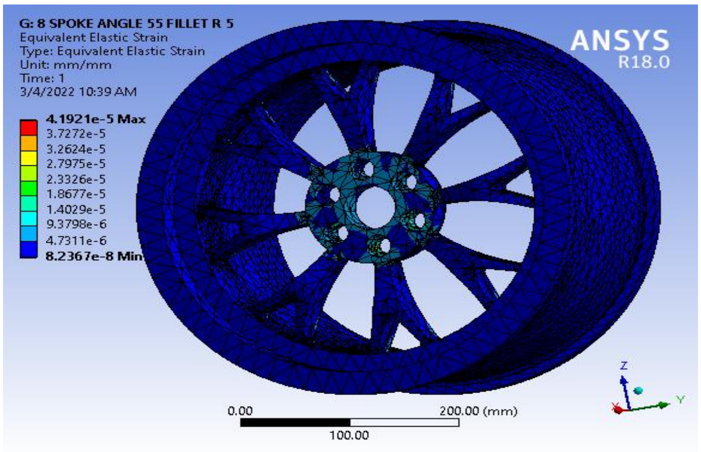

Fig-35: Equivalent Elastic Stress of 8 Spoke angle wheel rim with 55° Y spoke angle

8. RESULT:

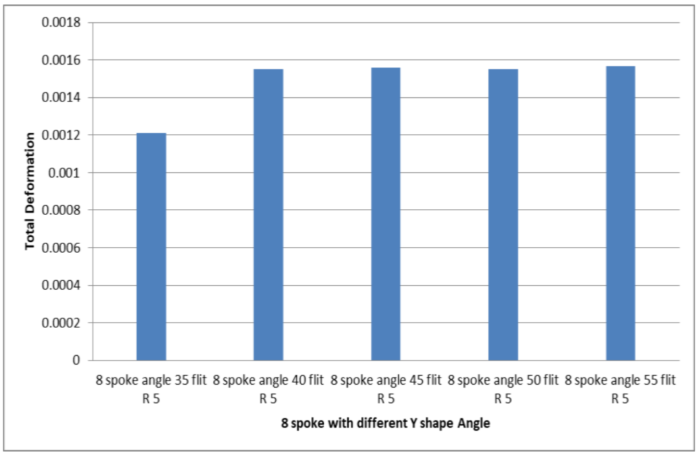

Fig-36: Total deformation of different Y shape alloy spoke angle

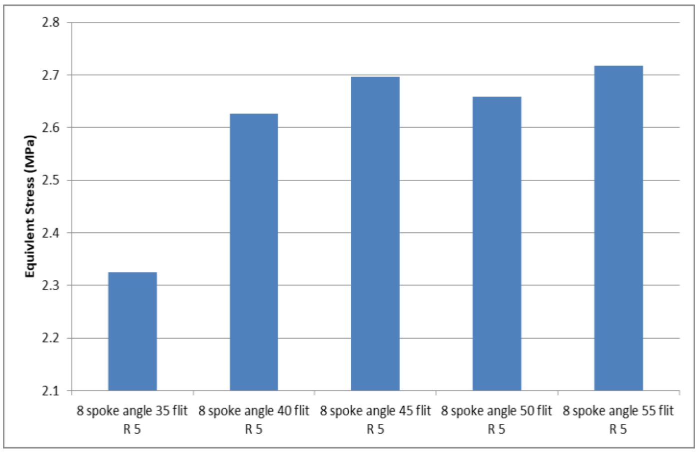

Fig-37: Equivalent Stress with respect to different 8 Spoke ally wheel angle of Y shape

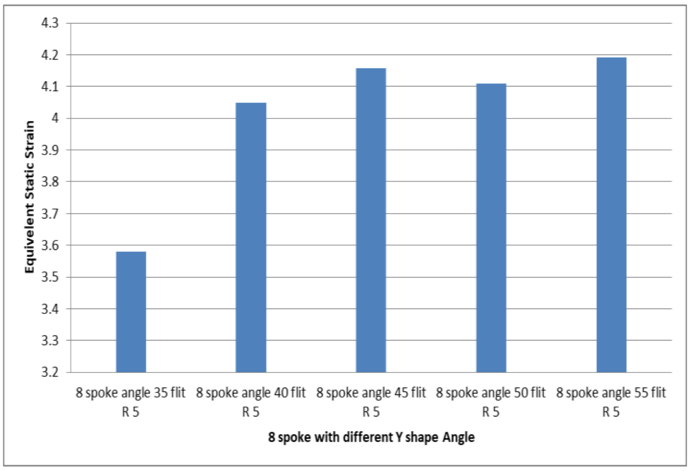

Fig-38: Equivalent Elastic Stress with respect to different 8 Spoke alloy wheel angle of Y shape

9.CONCLUSION:

For the structural analysis for the remote force the magnitude applied is 1000N and for the pressure which applied on the wheel is 245kPa.

Therefore, so comparing the wheels with the total deformation occurred alloy wheels are better than the steel wheel, and comparing the both the alloy wheels multi-spoke alloy wheel is better than the 6-spoke alloy wheel.

Since the alloy wheel have some dis-advantages then also considering the results alloy wheels have better structural tendency than the steel wheels and if the spokes are

1) Static and dynamic analysis of wheel rim can be done together.

2) For static load car weight can be considered and for dynamic condition acceleration load can be considered.

3) For practical realistic condition harmonic excitation can be considered.

4) All the above factors can be considered on three different materials which after comparing in Ansys software; will suggest which the best material.

REFERENCES:

1. P. Meghashyam, S. Girivardhan Naidu and N. Sayed Baba, Design and Analysis of Wheel Rim using CATIA & ANSYS, International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 2, Issue 8, August 2013.

2. Sudhakar Mishra, Dr. L.P. Singh, Structural and Material Analysis of an Automobile Wheel Rim using ANSYS, International Research Journal of Engineering and Technology, Volume 06 Issue 1, Dec 2019.

3. Mr. Sunil Prashanth Kumar, Muhammad Mansoor P, Vishak Vignesh, Abhijeet Kumar, Mordi Sangma, Design And Analysis of Automobile Wheel Rim International Research Journal Of Engineering And Technology (Irjet) E-Issn: 2395-0056 Volume: 08 Issue: 07 | July 2021

4. Manugonda Babu, Dr. V.S. Hariharan, Modelling and Analysis of Automotive Wheel Rim, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 4, April 2016.

5. M.Ravichandra, S. Ramesh Kumar babu, A.Salmon, P.Nagaraju, Design and Structural Analysis of Alloy Wheels for Light Weight Vehicles , IOSR Journal of Mechanical and Civil Engineering, Volume 12, Issue 6 Ver. V (Nov. - Dec. 2015), PP 73-82

6. https://en.wikipedia.org/wiki/Alloy_wheel